The HERA-B First Level Trigger

Joachim Flammer, DESY Hamburg

Abstract

The Hera-B detector aims to measure CP violation in the B meson system. Together with the B mesons a 6 orders of magnitude larger background of minimum bias interactions is produced. A highly selective and efficient trigger system is therefore needed to acquire a sufficient sample of B-decays. A parallel and pipelined system of approximately 100 processors has been designed to perform this job. The network reduces a 10 MHz input rate by a factor of 200 with a latency of less than 12µs. The First Level Trigger is divided into three parts: The Track Finding Unit (TFU) to reconstruct the tracks, the Track Parameter Unit (TPU) to calculate the kinematic parameters of the tracks and the Trigger Decision Unit (TDU) to calculate the invariant mass of the combined tracks. The final First Level Trigger decision is based on the properties of the reconstructed pairs of tracks. This is mainly targeting at $J/\Psi \rightarrow l^+ l^-$.

In this poster, the different parts of the First Level Trigger will be presented together with some simulation results.

General Setup & Introduction

Input rate ↓ 10 MHz

Latency: max. 12.3 µs
(buffers of detector are 128 cells deep: 128 * 96 ns = 12.3 µs)

1. Find initial track candidates: Primary search for track candidate (track seed) in MUON, ECAL and High-P_T system — **Pretrigger**
2. Update track candidates: Recursive search for hits in tracking layers, compatible with track candidates — **TFU**
3. Reconstruct kinematic parameters: Derive kinematic parameters of the track in the interaction vertec from the track geometry behind the magnet — **TPU**
4. Reconstruct invariant mass: Combine track candidates, calculate pair invariant mass and generate a trigger decision — **TDU**

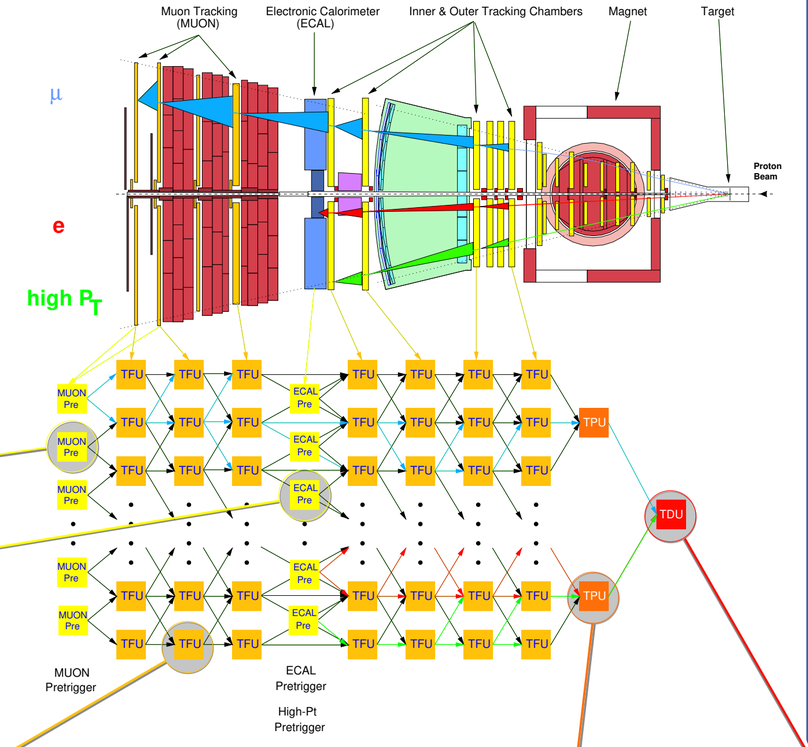
Input data: 100,000 wire bits from 7 layers of tracking chambers with 3 stereo views each → 1 Terabit/s

Output rate ↓ 50 kHz

Features:

- asynchronous pipeline architecture (50 MHz)
- Lookup table based calculations
- data for the last 128 BX are kept on the boards

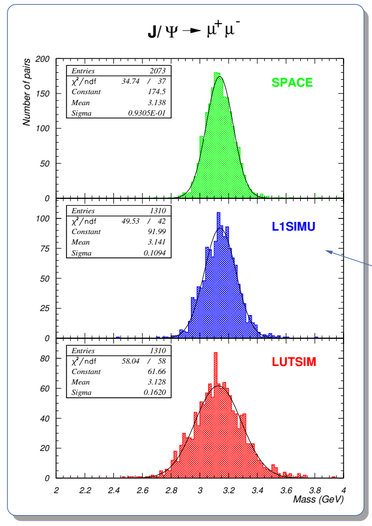
} special designed processor boards

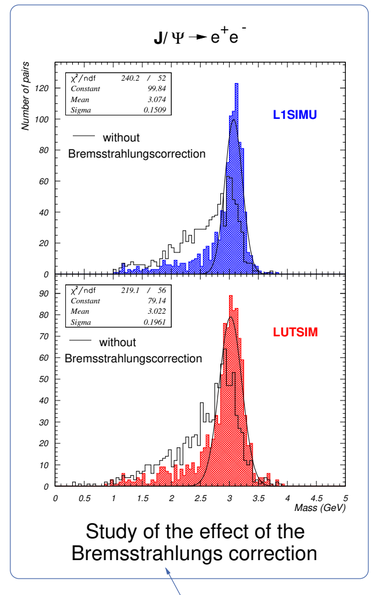


Simulation

Different simulation modes to study the influence of various parameters on the invariant mass:

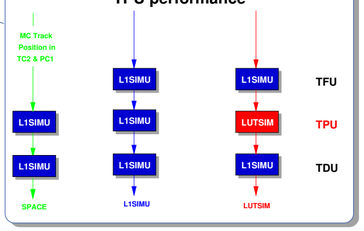
- Direct reconstruction out of **MC Data**
- Simulation package **L1SIMU**
  Complete reconstruction including pretrigger, TFU, TPU and TDU
  Floating point calculations
- Simulation Package **LUTSIM**
  includes also hardware logic (lookup tables)





Study of the effect of the Bremsstrahlungs correction

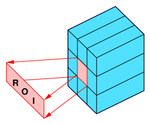
Combination of different simulation to study TPU performance



Pretrigger

Electromagnetic calorimeter

Cluster Candidates

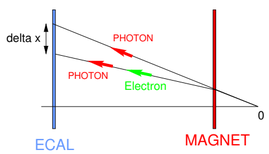


cluster with large deposited energy

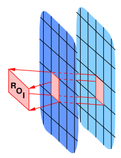
for electron candidates

Bremsstrahlungs Correction

Correction for Bremsstrahlung produced in front of magnet (not bent by magnet) => measure cluster at distance delta x in addition



Muon system



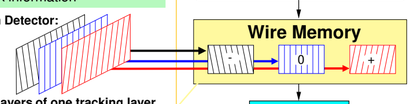
PAD double coincidence

for muon candidates

Track Finding Unit (TFU)

Message Receiver:
- receives Messages with track information

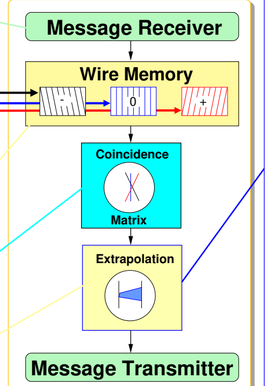
Data from Detector:

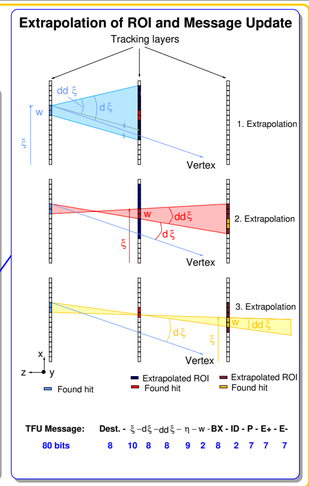


Wire Memory:
- stores wire information from detector for the tracking layer part which is associated to TFU (3*384 wires)

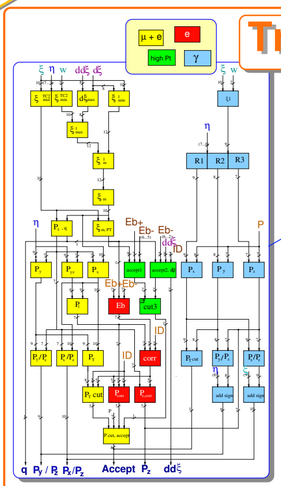
Coincidence Matrix:
- checks the possible coincidences between the three stereo views

Extrapolation:
- extrapolate track to next tracking layer and refines track information





Track Parameter Unit (TPU)



Message Receiver

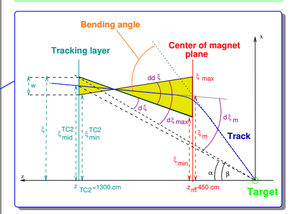
Lookup tables
calculates kinematic parameters for found lepton tracks

Kinematical cuts

Double track rejection

Message Transmitter

Message Receiver:
- receives message of a track followed through all tracking chambers



Kinematical cuts:
- applies cuts on momentum and P_T

Double track rejection:
- suppresses double tracks

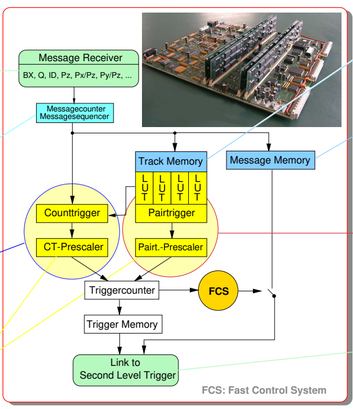
Trigger Decision Unit (TDU)

Message Receiver:
- receives Message from TPU

Message Counter/-Sequencer:
- sorting of track parameters of found leptons according to BX number and arrival time of message

Counttrigger
- Counts numbers of electrons, muons, hadrons and photons
- Extra counters for high P_T particles
- Trigger on threshold value of a certain kind of particle

Prescaler:
- downscaling of trigger rates



Track Memory:
- Storage of kinematic parameters which are needed for invariant mass calculation

Message Memory:
- Storage of complete track message while waiting for trigger decision

Pairtrigger
- Triggers on lepton pairs by calculating invariant mass using Lookup tables (LUT) (up to 4 messages per cycle)
- applies Mass cut

Link to Second Level Trigger:
- Passes complete track parameters to SLT for track refit

Presented during the SLAC summer institute 1999. Inquiries to joachim.flammer@desy.de